

The April-May 2015 Nepal Earthquake Sequence

The April 25, 2015 M 7.8 Gorkha Earthquake and its Aftershocks,
including the May 12, 2015 M 7.3 Event

Earthquake Educational Slides

Created & Compiled by Gavin Hayes

U.S. Geological Survey, National Earthquake Information Center

Contributions from:

Rich Briggs, Kishor Jaiswal, Dan McNamara, David Wald, Harley Benz,
Mike Hearne, Paul Earle

USGS Geological Hazards Science Center

M7.8, 06:11 UTC (11:56 locally) April 25, 2015



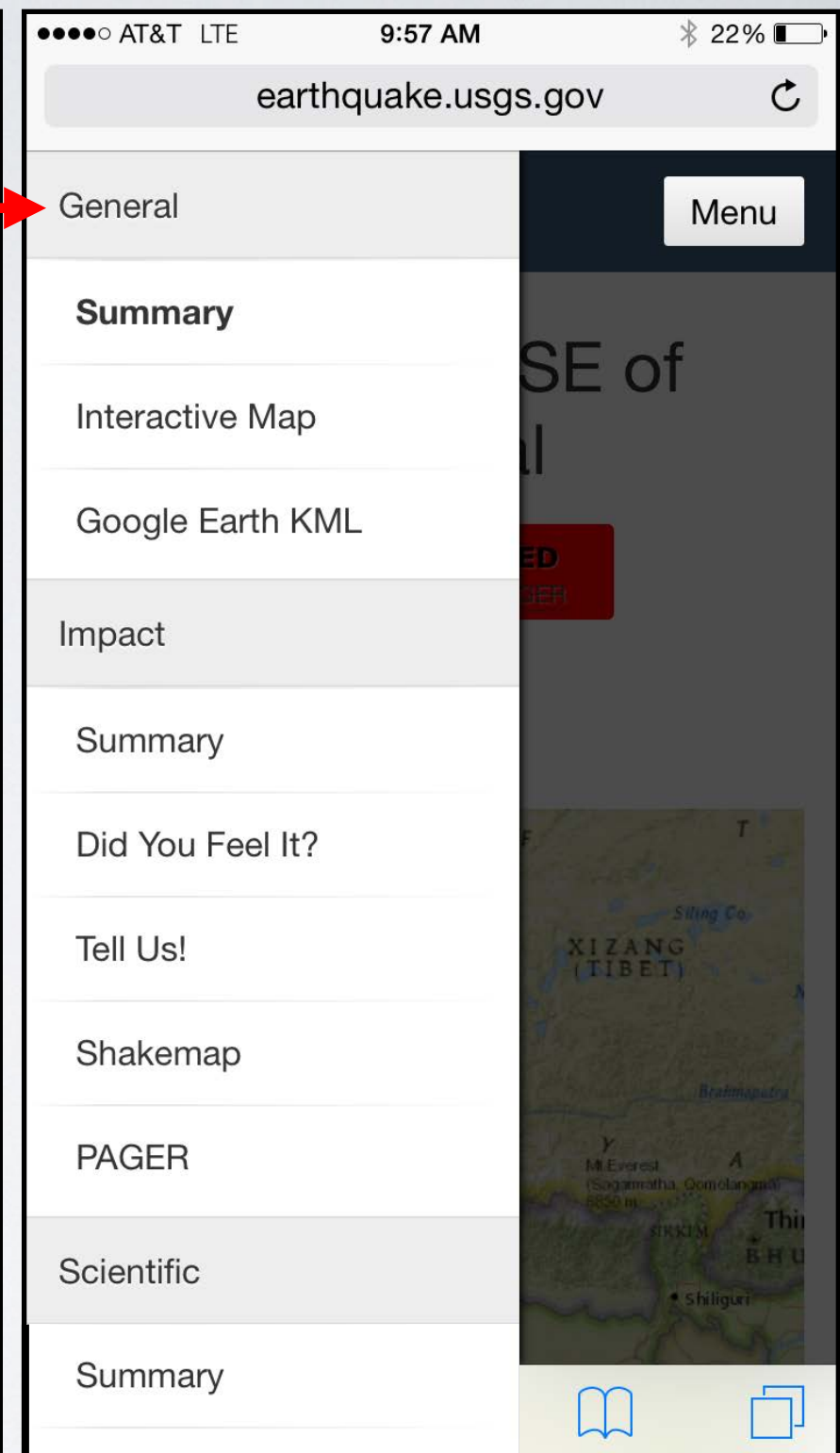
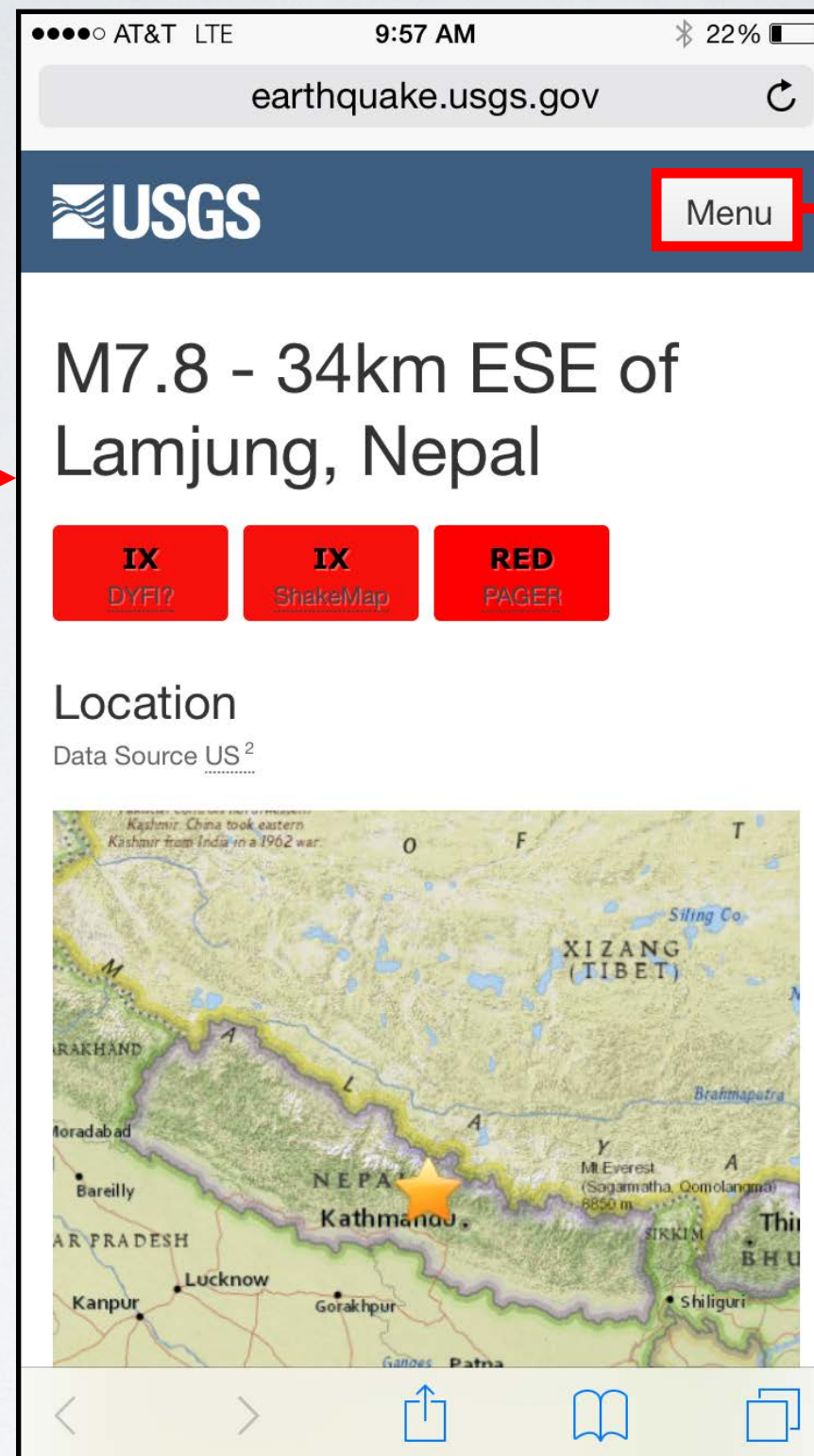
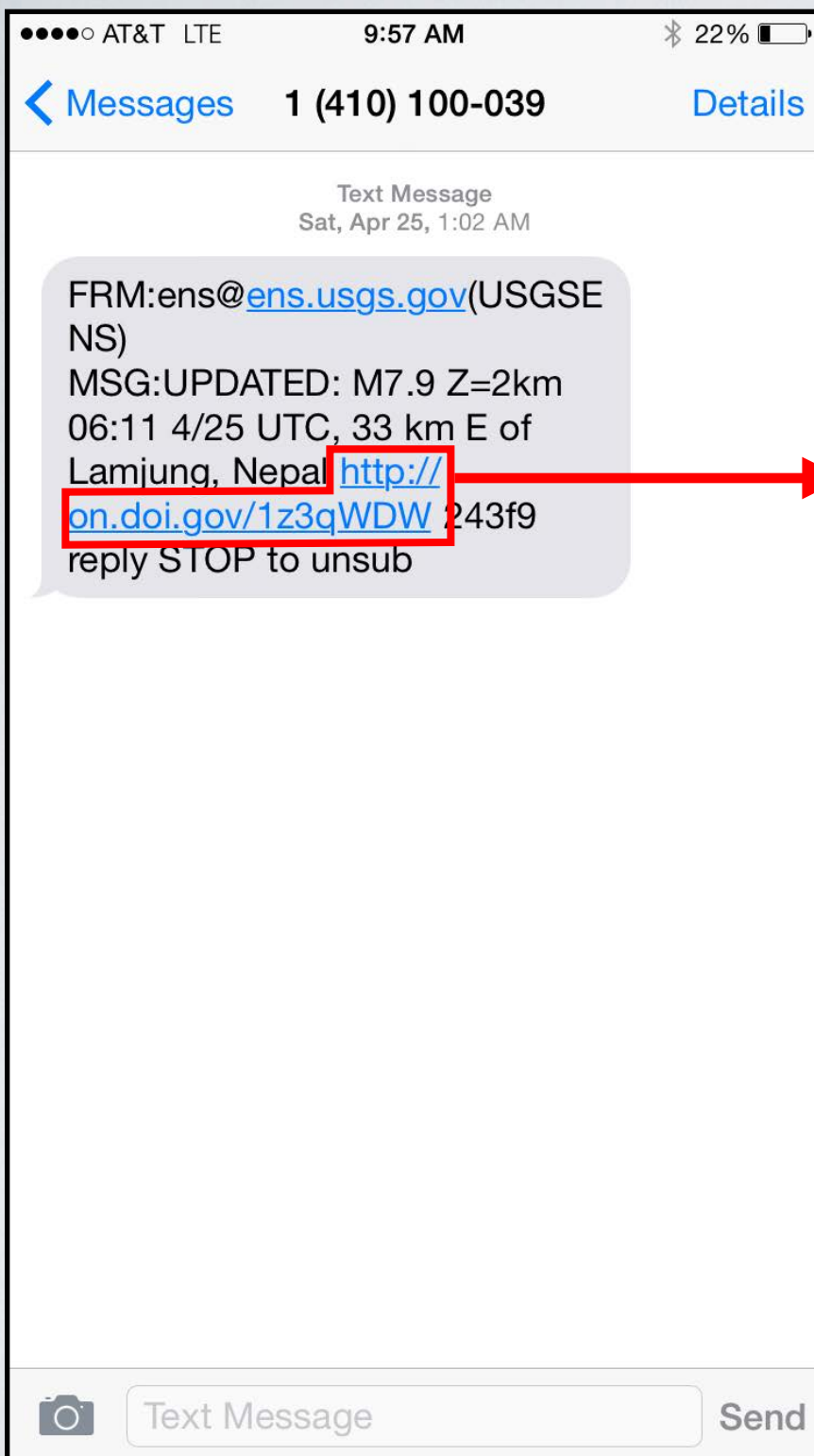
image from mashable.com;
Narendra Shrestha, EPA

Mainshock fatalities ~ 8,500 (as of 05/15)
05/12 Aftershock: fatalities > 100

USGS Event Page: http://earthquake.usgs.gov/earthquakes/eventpage/us20002926#general_summary

USGS Earthquake Summary Poster: <http://earthquake.usgs.gov/earthquakes/eqarchives/poster/2015/20150425.php>

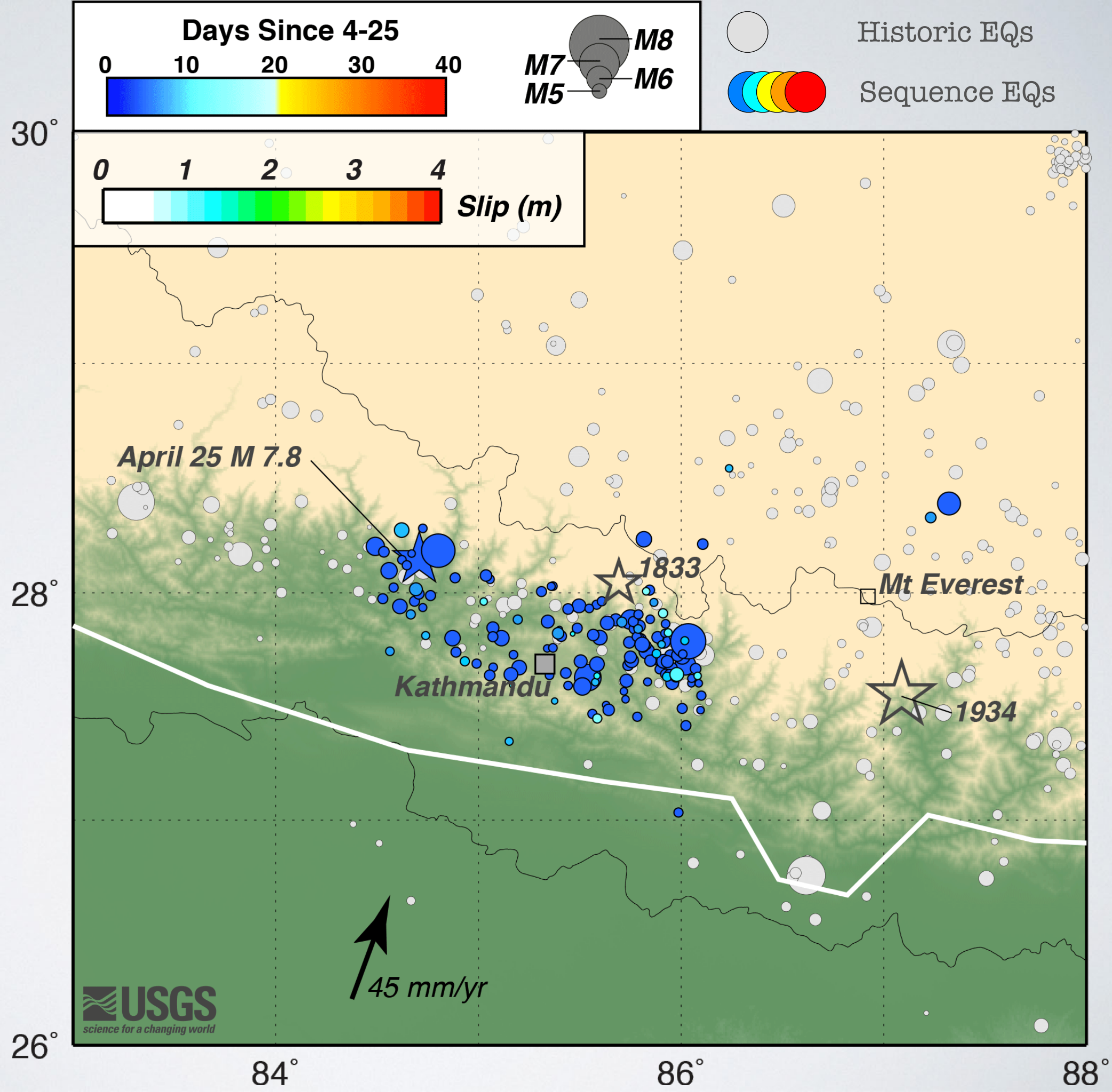
Earthquake Notification



Event pages linked directly from text messages; instant access to all event-based info in new, phone-friendly web format.

Overview

M 7.8 mainshock
on 04-25, ~80 km
NW of Kathmandu.

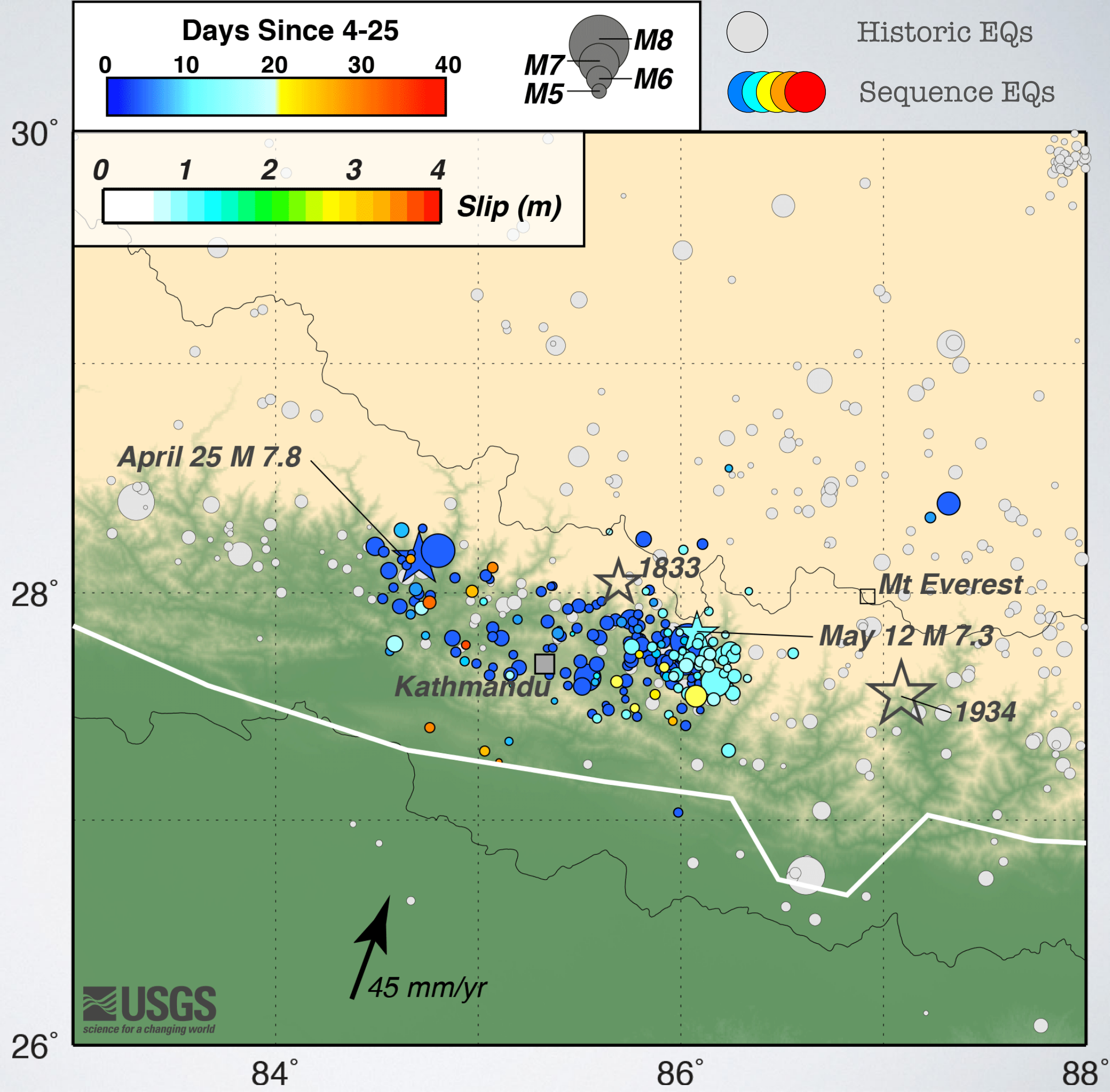


Overview

M 7.8 mainshock
on 04-25, ~80 km
NW of Kathmandu.

~100 subsequent
aftershocks, most
east of mainshock.

M 7.3 aftershock
on 05-12, ~80 km
NE of Kathmandu.



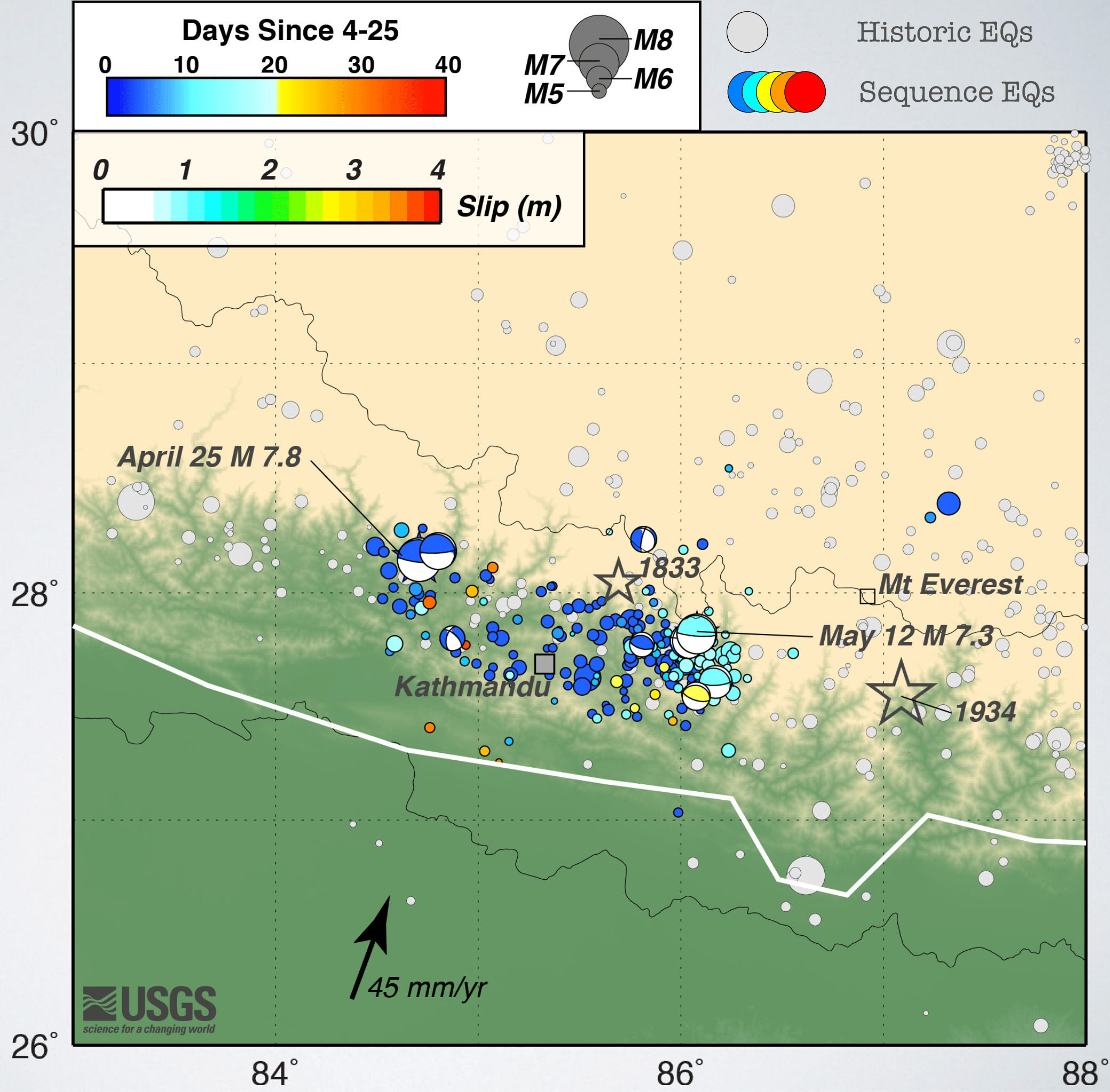
Overview

M 7.8 mainshock on 04-25, ~80 km NW of Kathmandu.

~100 subsequent aftershocks, most east of mainshock.

M 7.3 aftershock on 05-12, ~80 km NE of Kathmandu.

Most EQs shallow angle thrust faulting; likely on decollement of Himalaya Thrust. Some normal fault aftershocks.

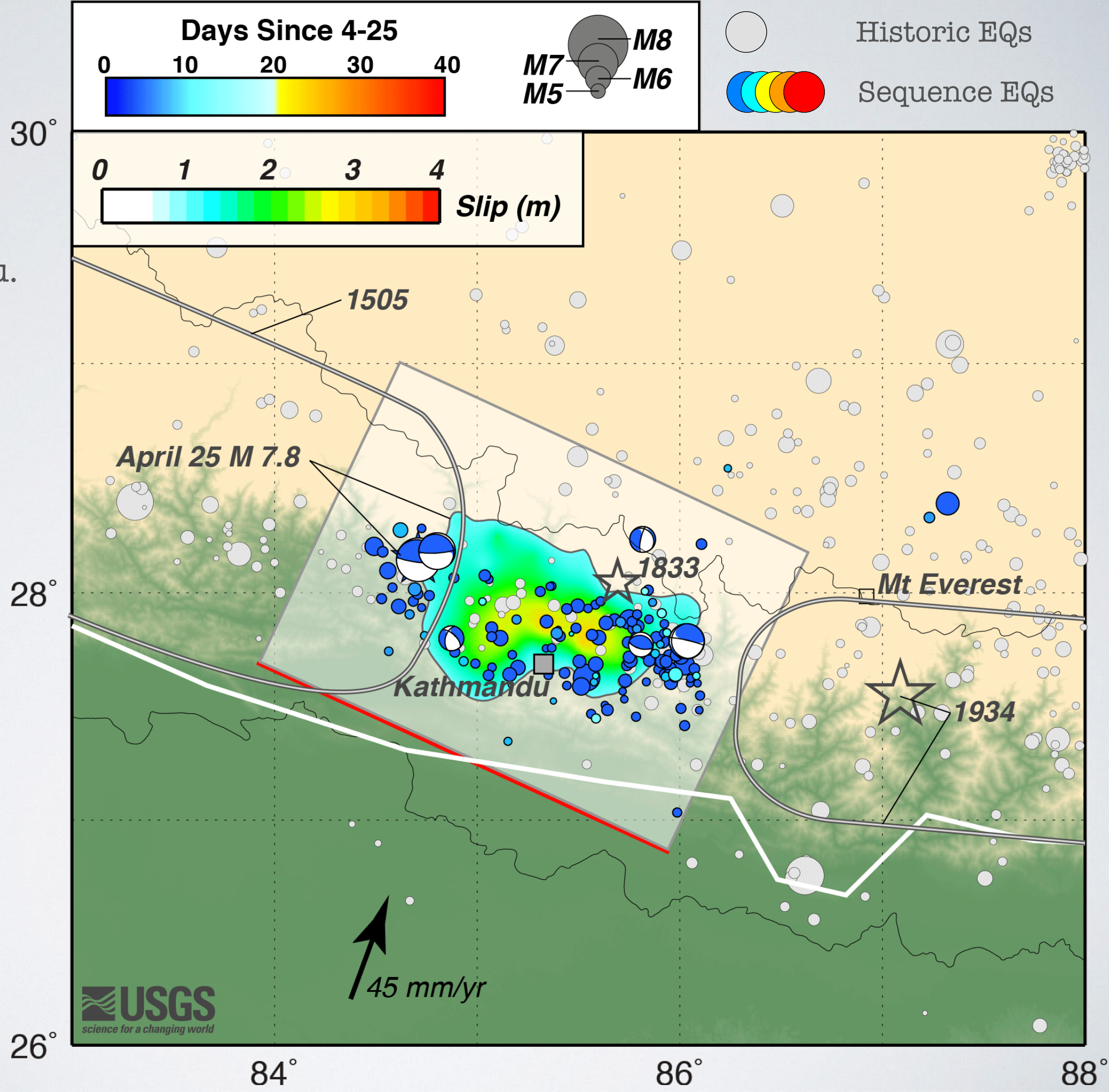


Overview

Mainshock slip directed east from hypocenter, towards Kathmandu.

Peak slip >4m.
Dimensions
~120 x 80 km.

Similar location
and extent to
1833 M~7.7 EQ.
Adjacent to 1934
M 8+ EQ.



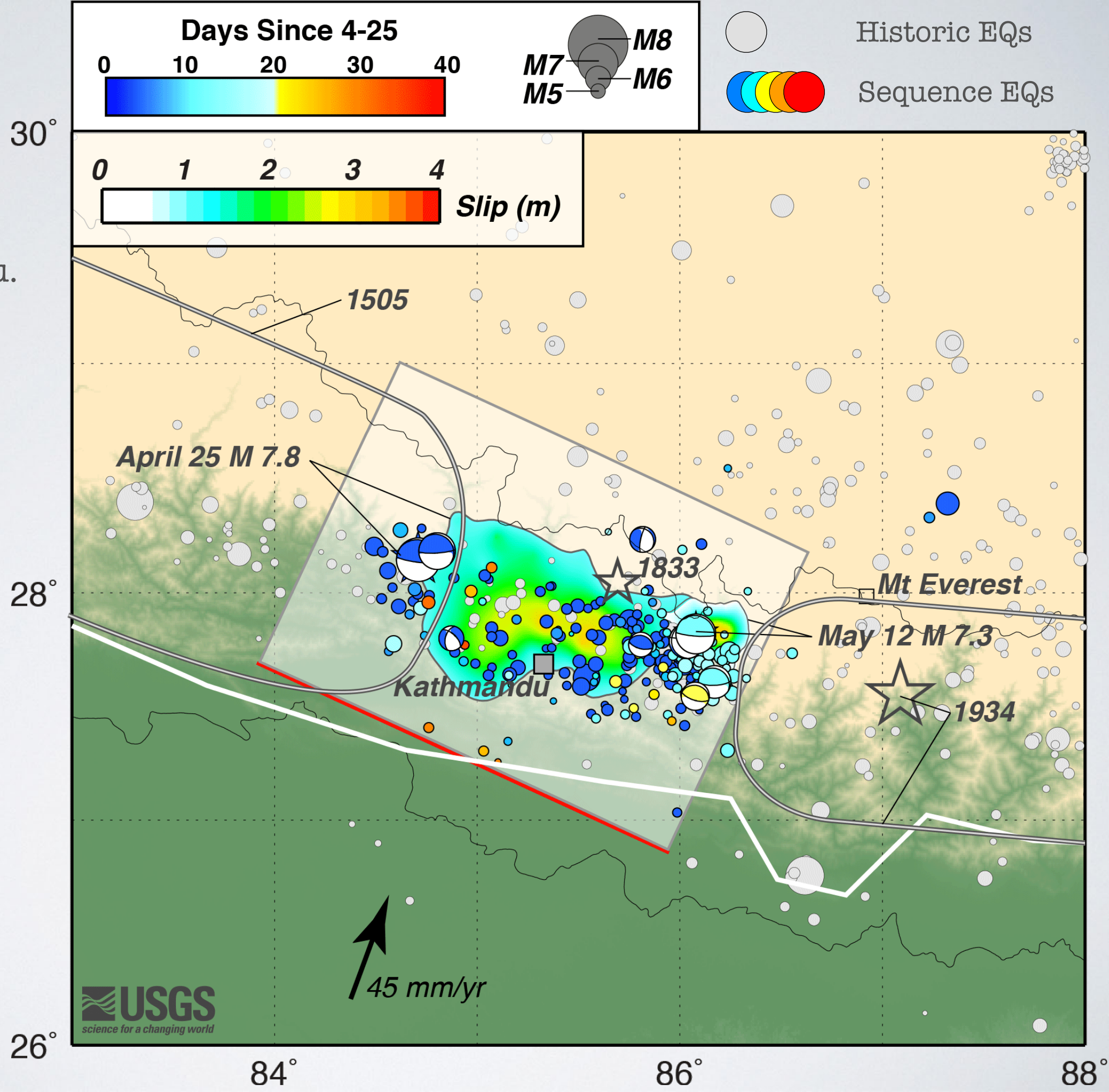
Overview

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Peak slip >4m.
Dimensions
~120 x 80 km.

Similar location
and extent to
1833 M~7.7 EQ.
Adjacent to 1934
M 8+ EQ.

M7.3 aftershock
at NE extent of
mainshock; slip
close to 4m,
dimensions
~40 x 30 km.
Resolvable NW
rotation wrt 4-25
EQ.



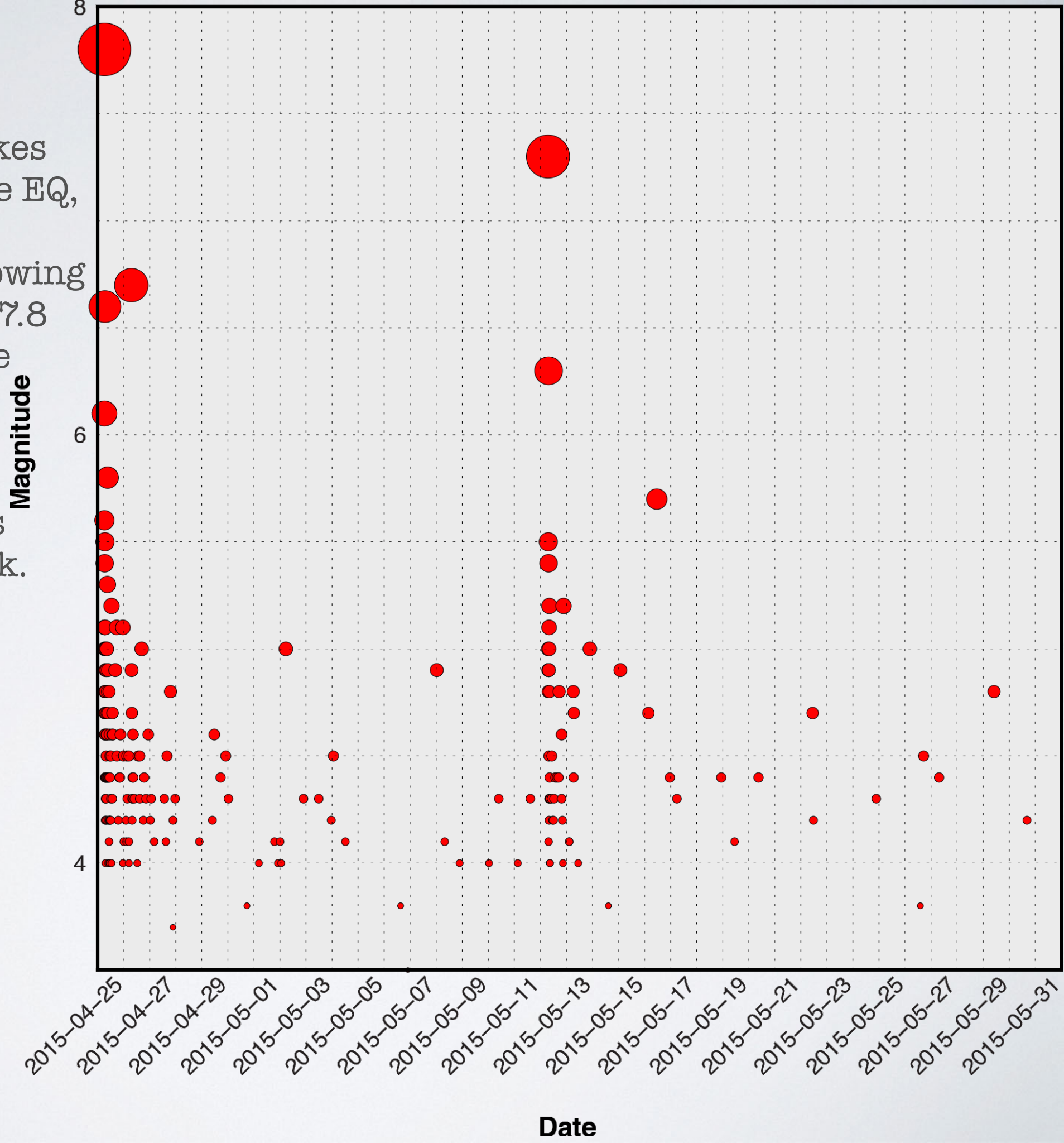
Time History

Aftershocks are earthquakes that occur following a large EQ, in the same general area as that EQ, during the following days-to-years. Both the M 7.8 Gorkha mainshock and the M 7.3 aftershock, have triggered aftershocks.

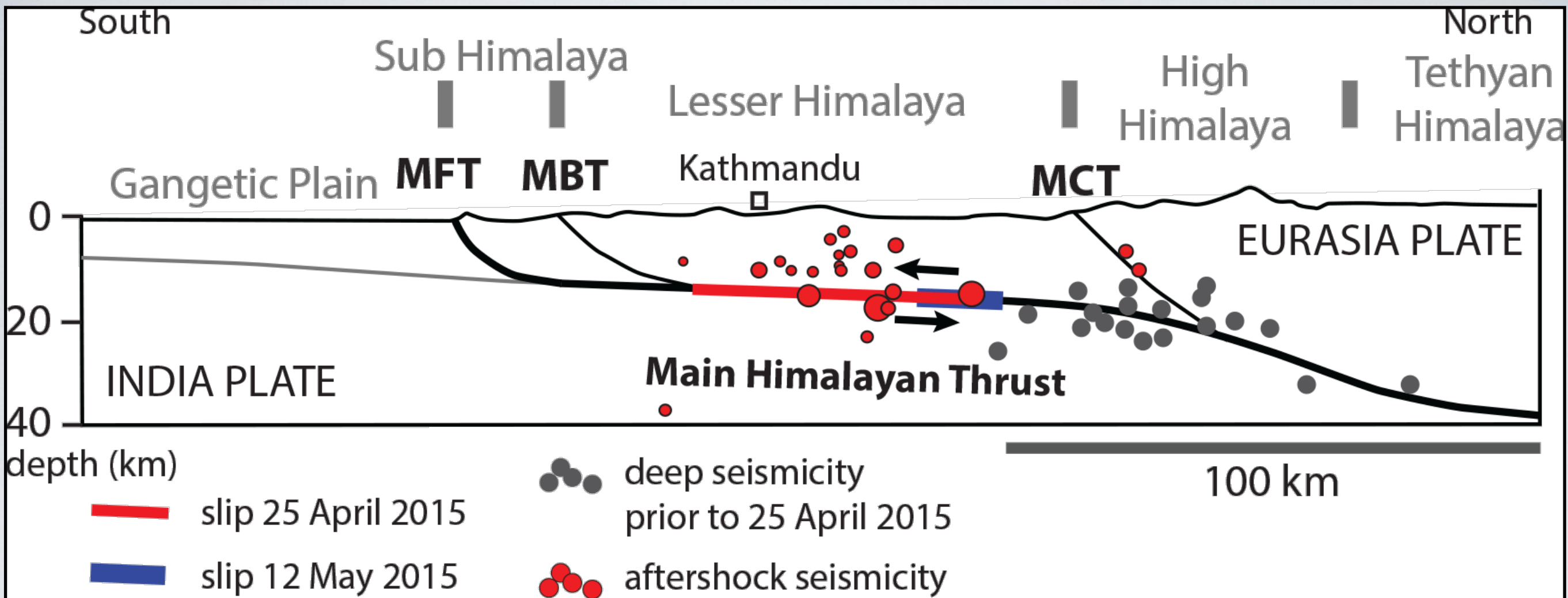
Two M 6.6-6.7 aftershocks within 48 hrs of mainshock.

Subsequent aftershock sequence decayed rapidly, until M7.3 aftershock on 05-12, 17 days after mainshock.

Increase in aftershock activity since M7.3 event, including a M6.3 aftershock soon after that EQ.



Tectonic Context - Cross-Section



Generalized cross section showing the approximate locations of slip during the 25 April and 12 May 2015 ruptures on the Main Himalayan Thrust, and approximate aftershock locations of both events.

MFT = Main Frontal Thrust, MBT = Main Boundary Thrust, MCT = Main Central Thrust.

Cross section generalized after Lave and Avouac, 2001 and Kumar et al., 2006.

Population per ~1km² from LandScan

Scale of Hazard

0

5

50

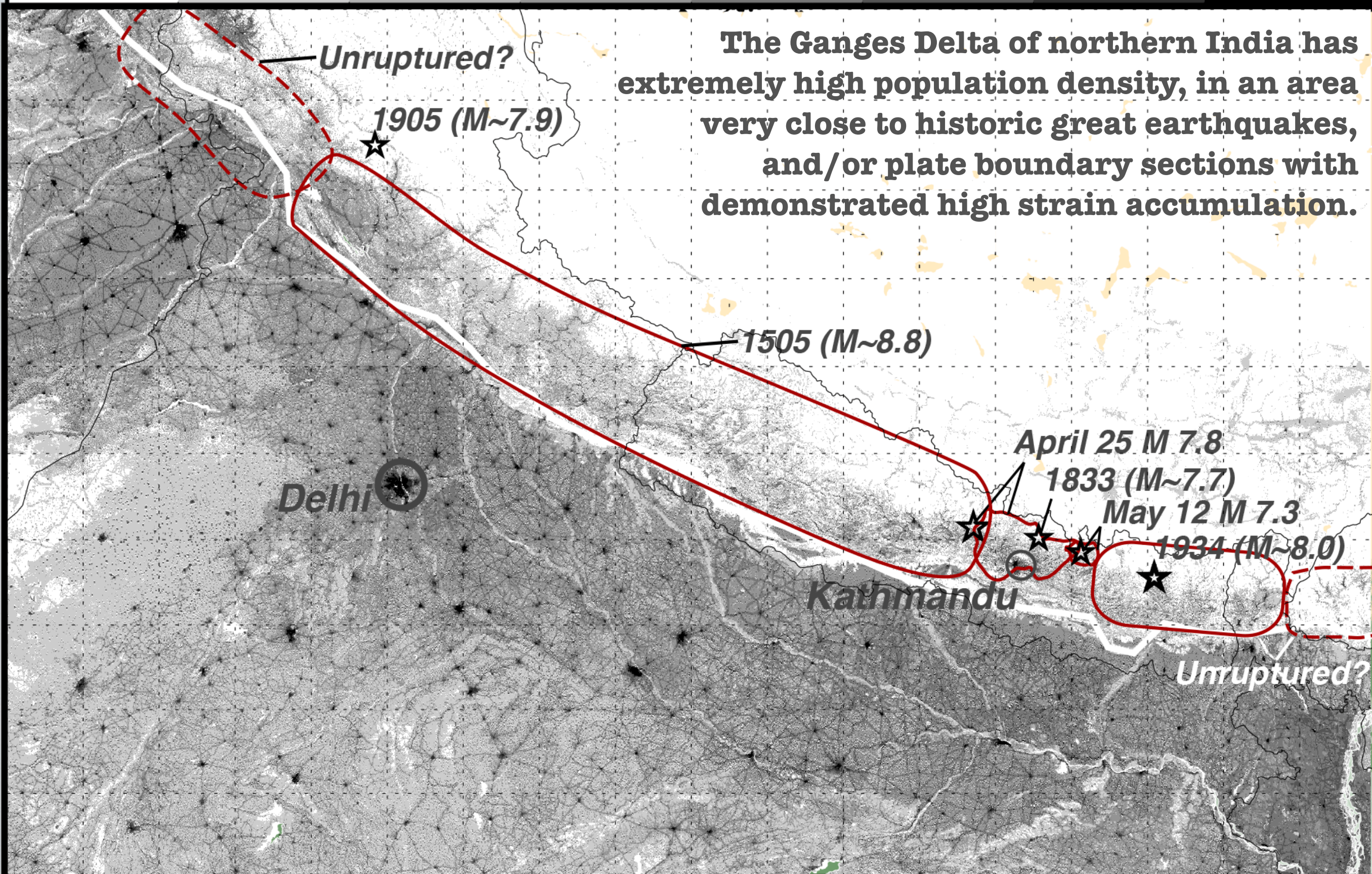
100

500

1000

5000

10000

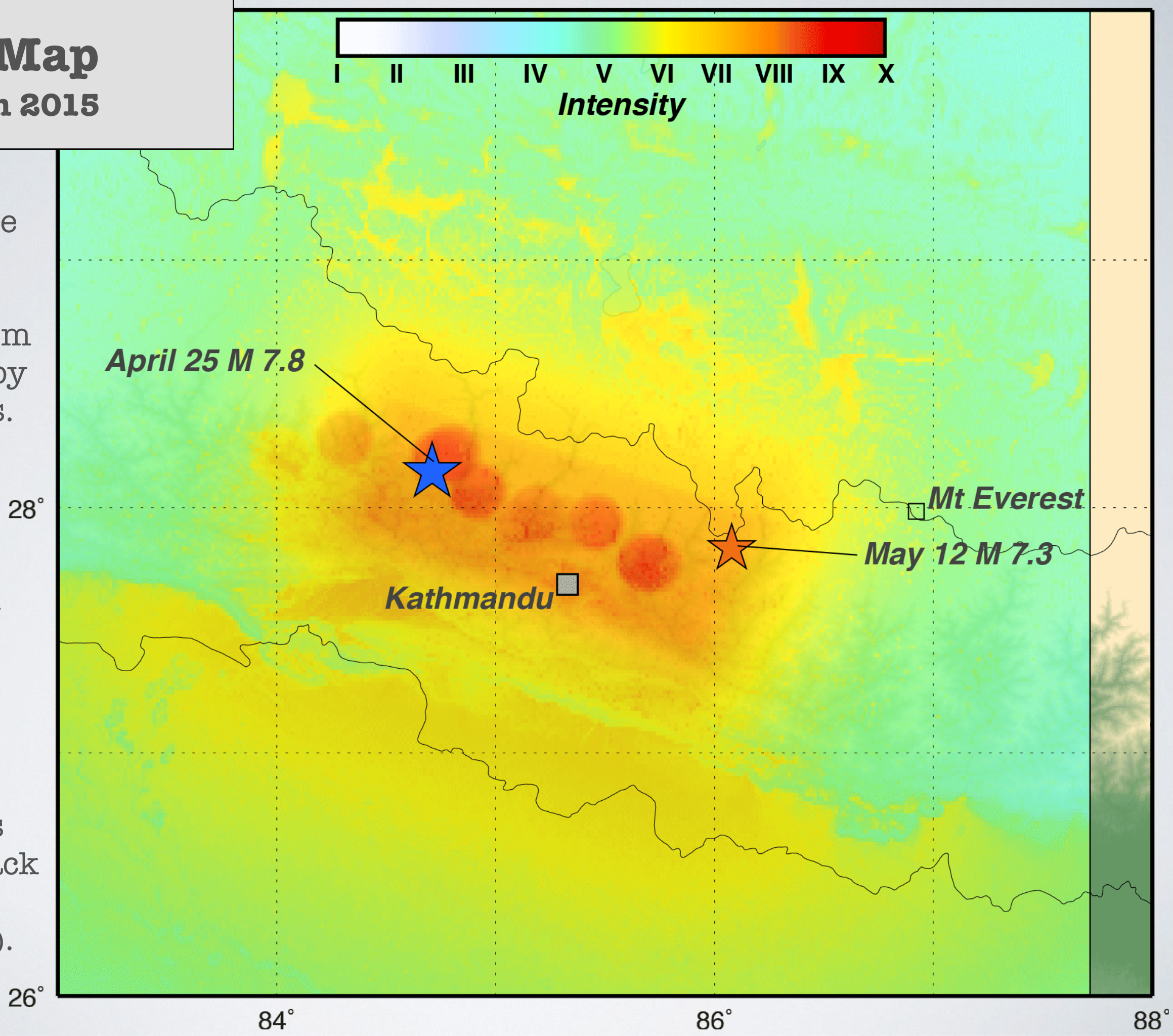


ShakeMap

April 25th 2015

Broad, very strong-severe shaking, elongated eastward from hypocenter by EQ finiteness.

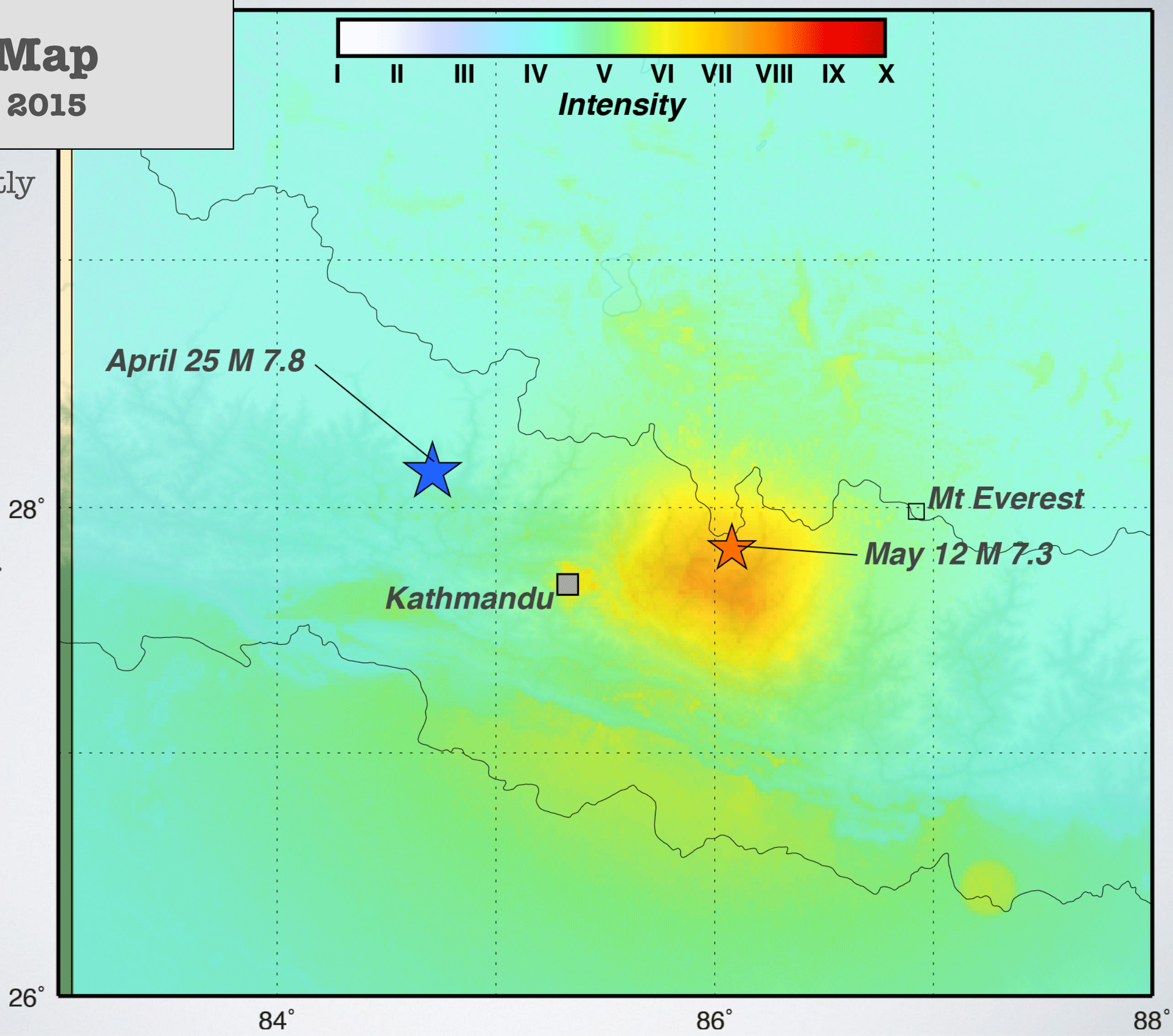
Shaking estimates in epicentral region are poorly constrained due to fewer intensity observations (as well as lack of strong motion data).



ShakeMap

May 12th 2015

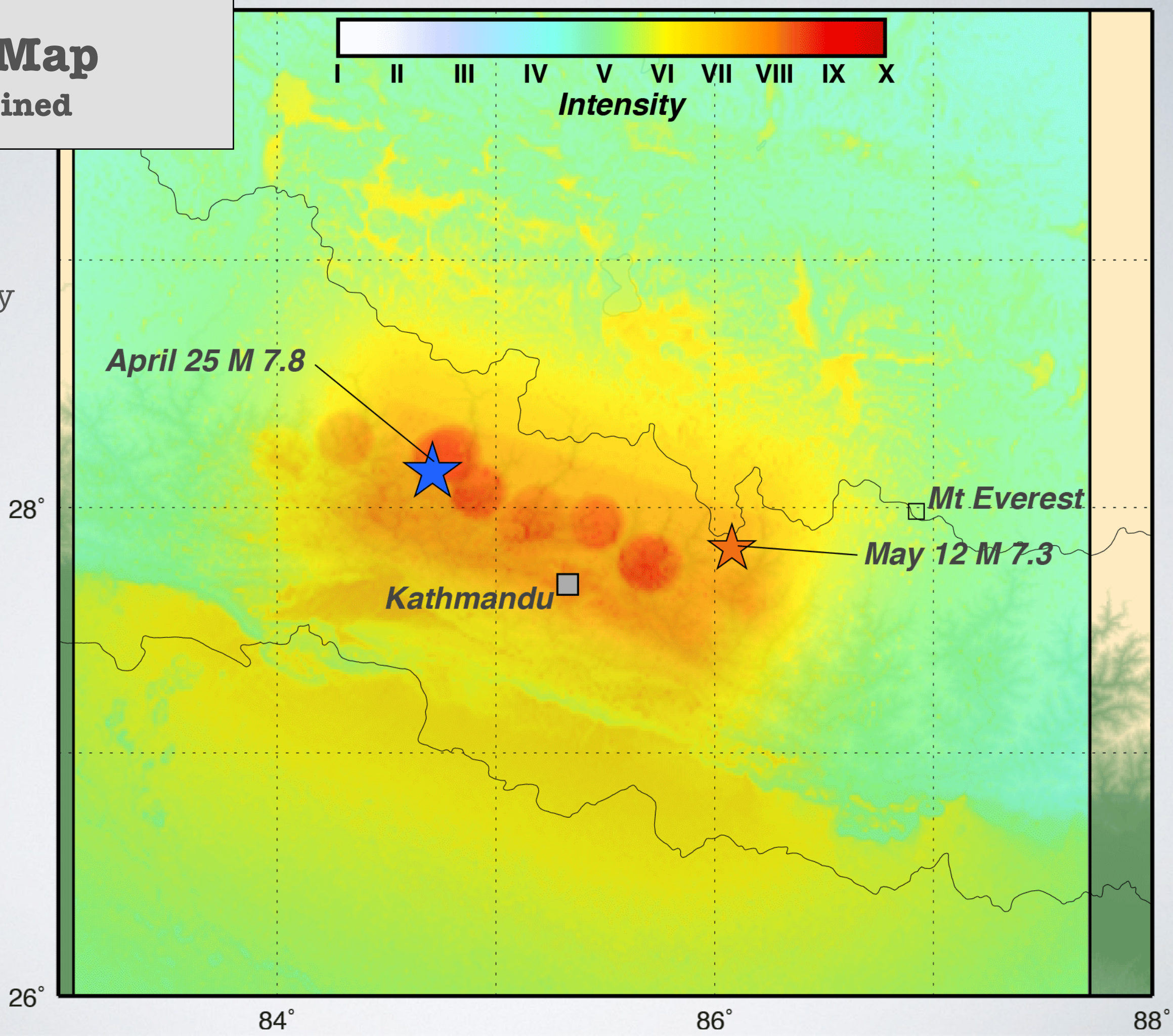
Predominantly strong-very strong shaking, focussed around aftershock hypocenter (smaller source dimensions).



ShakeMap

EQs Combined

Combined
shaking
intensity
dominated by
mainshock.

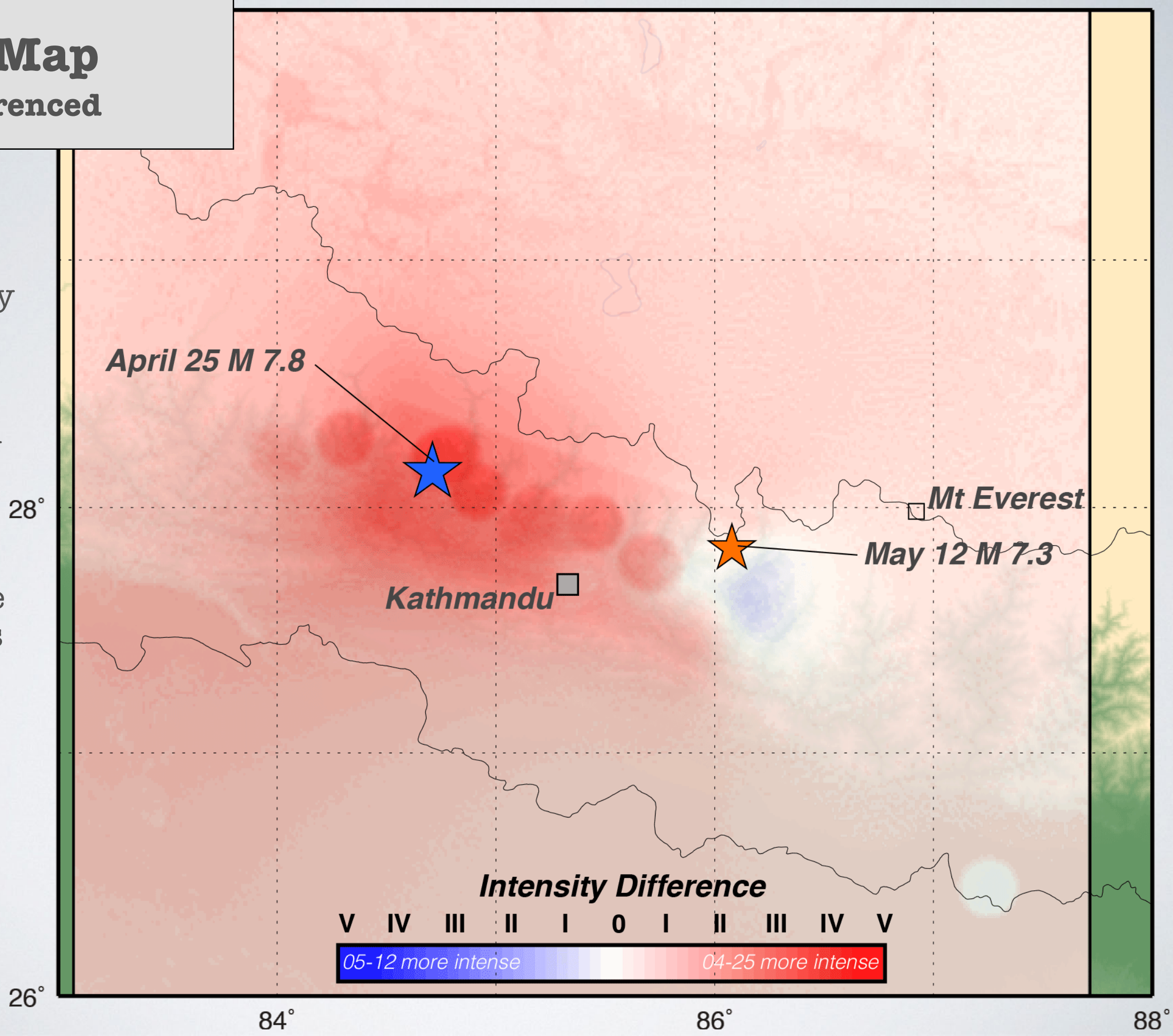


ShakeMap

EQs Differenced

Combined shaking intensity dominated by mainshock.

Aftershock shaking only higher than mainshock in eastern Nepal, where population is lower.



PAGER

April 25th 2015

Combination of broad, very strong-severe shaking leads to high exposure and thus an international-level alert; large numbers of fatalities, and economic losses.

Median loss estimation:

~ 9,000 fatalities

~ \$4B direct economic loss

- EQ occurred during work hours (many people were outdoors)

- Housing in rural areas are one-two story construction, with a relatively lighter roof (Tins/GI sheets). High damage rate even at low shaking, but often leads to low fatality rates.

- Majority of newer, multi-story buildings performed reasonably well (sustained damage, but did not collapse).



science for a changing world

M 7.8, NEPAL

Origin Time: Sat 2015-04-25 06:11:26 UTC (11:56:26 local)

Location: 28.15°N 84.71°E Depth: 15 km

Earthquake
Shaking



Red
Alert



ANSS

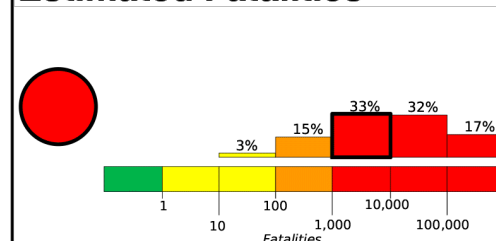


USAID
FROM THE AMERICAN PEOPLE

PAGER
Version 7

Created: 1 week, 2 days after earthquake

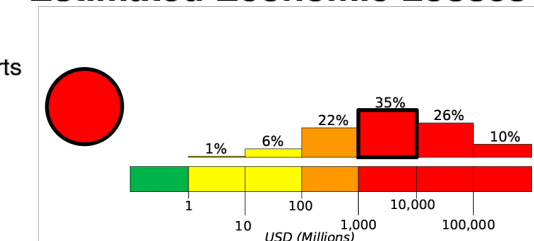
Estimated Fatalities



Red alert for shaking-related fatalities and economic losses. High casualties and extensive damage are probable and the disaster is likely widespread. Past red alerts have required a national or international response.

Estimated economic losses are 10-70% GDP of Nepal.

Estimated Economic Losses

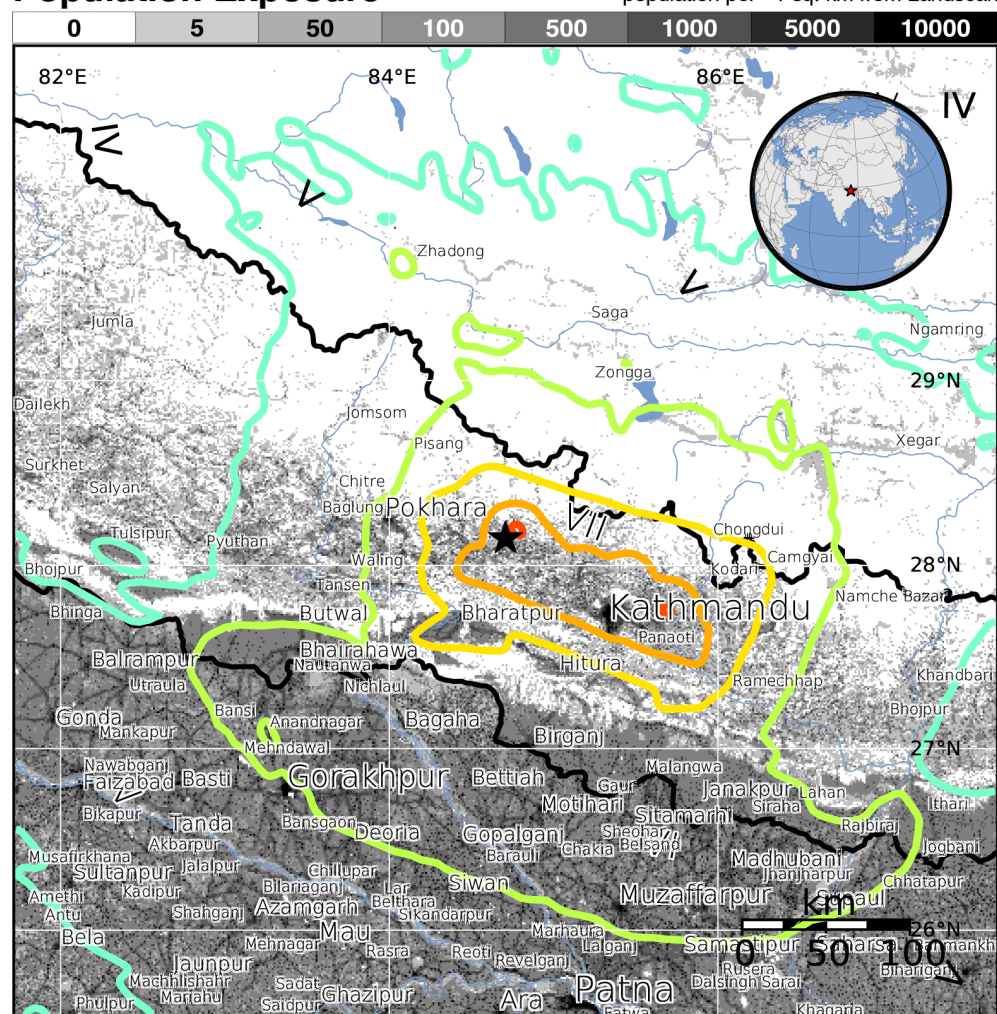


Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)	- *	- *	7,053k*	82,752k*	55,057k	2,355k	4,483k	86k	0
ESTIMATED MODIFIED MERCALLI INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure



Structures:

Overall, the population in this region resides in structures that are highly vulnerable to earthquake shaking, though some resistant structures exist. The predominant vulnerable building types are unreinforced brick masonry and rubble/field stone masonry construction.

Historical Earthquakes (with MMI levels):

Date (UTC)	Dist. (km)	Mag.	Max MMI(#)	Shaking Deaths
1980-07-29	364	5.5	VII(18k)	0
1980-07-29	388	6.5	IX(11k)	100
1988-08-20	244	6.8	VIII(12k)	1k

Recent earthquakes in this area have caused secondary hazards such as landslides and liquefaction that might have contributed to losses.

Selected City Exposure

from GeoNames.org

MMI City	Population
VIII Kathmandu	1,442k
VIII Patan	183k
VIII Kirtipur	45k
VIII Bhaktapur	< 1k
VIII Banepa	17k
VIII Panaoti	28k
VI Pokhara	200k
VI Muzaffarpur	333k
V Gorakhpur	674k
V Patna	1,600k
V Dhankuta	22k

bold cities appear on map

(k = x1000)

PAGER content is automatically generated, and only considers losses due to structural damage.

Limitations of input data, shaking estimates, and loss models may add uncertainty.

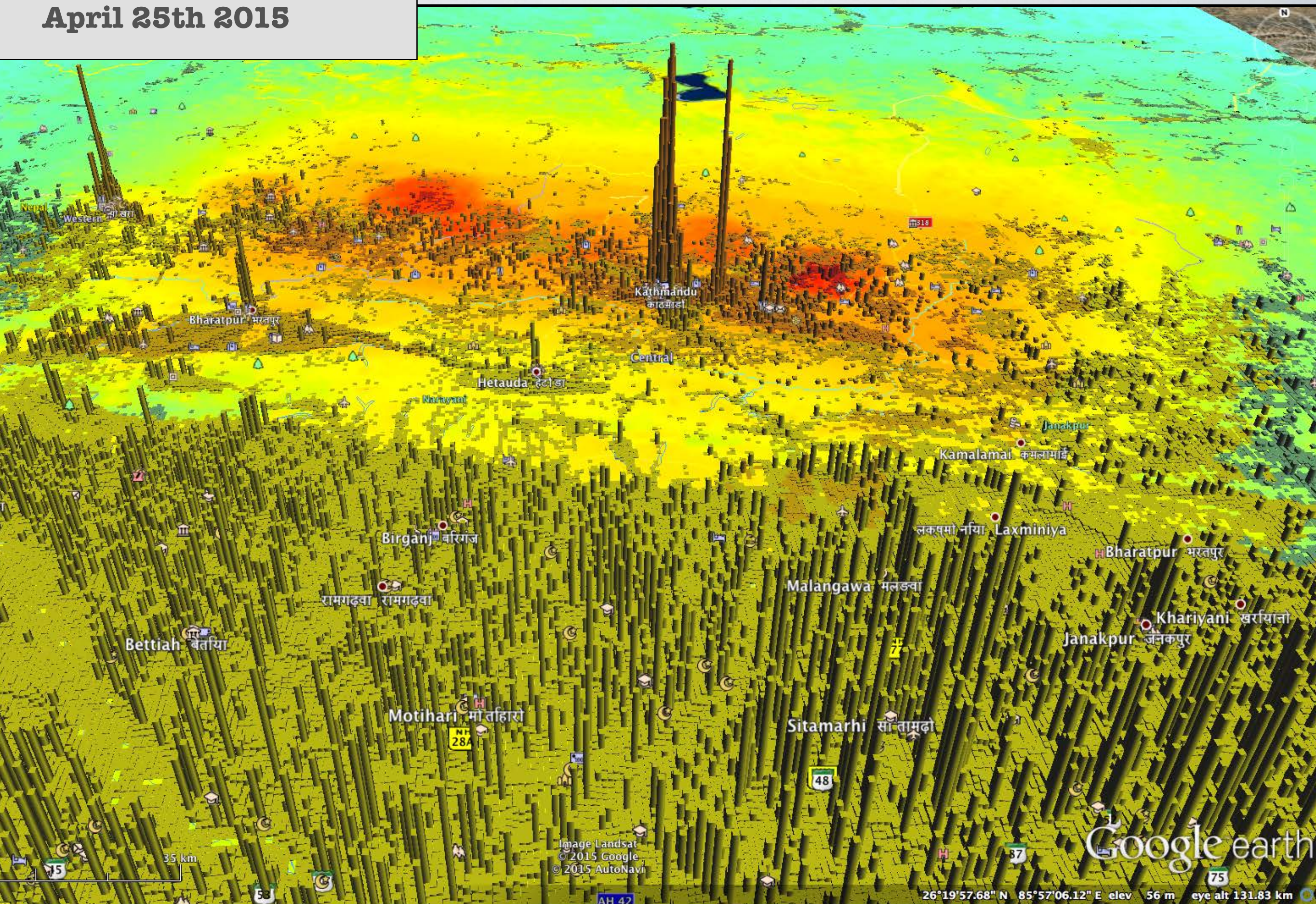
<http://earthquake.usgs.gov/pager>

Event ID: us20002926

Exposure

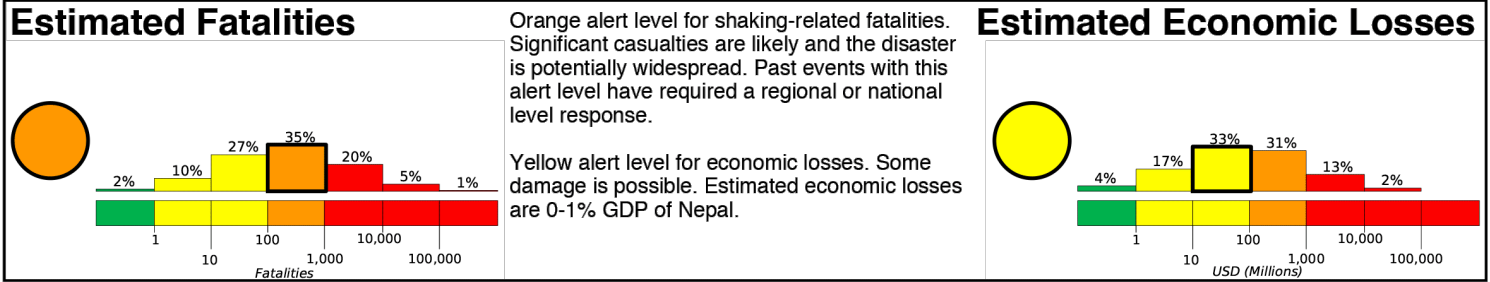
April 25th 2015

bars represent population/km²; color shaking intensity
by Kishor Jaiswal, USGS GHSC



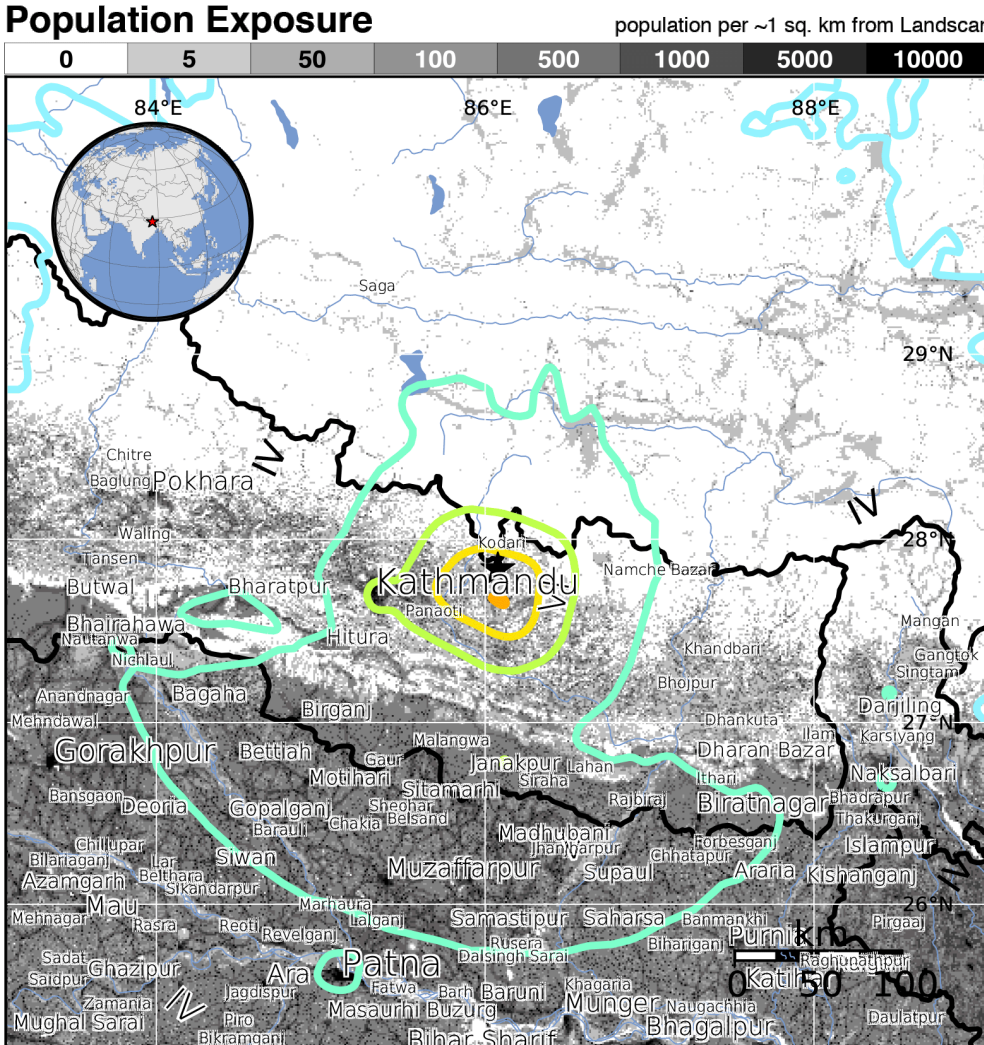
PAGER
May 12th 2015

Smaller sized EQ, and smaller source dimensions, leads to strong-very strong shaking in a more focussed, lower population area.
Median loss estimation:
~ 160 fatalities
~ \$60M direct economic loss



ESTIMATED POPULATION EXPOSURE (k = x1000)		- - *	26k*	95,415k*	60,510k	3,886k	304k	67k	0	0
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
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*Estimated exposure only includes population within the map area.



Structures:
Overall, the population in this region resides in structures that are highly vulnerable to earthquake shaking, though some resistant structures exist. The predominant vulnerable building types are unreinforced brick with mud and unknown/miscellaneous types construction.

Historical Earthquakes (with MMI levels):

Date (UTC)	Dist. (km)	Mag.	Max MMI(#)	Shaking Deaths
1998-09-03	77	5.6	VII(21)	0
1974-03-24	17	5.7	VIII(598)	0
1988-08-20	131	6.8	VIII(12k)	1k

Recent earthquakes in this area have caused secondary hazards such as landslides and liquefaction that might have contributed to losses.

Selected City Exposure

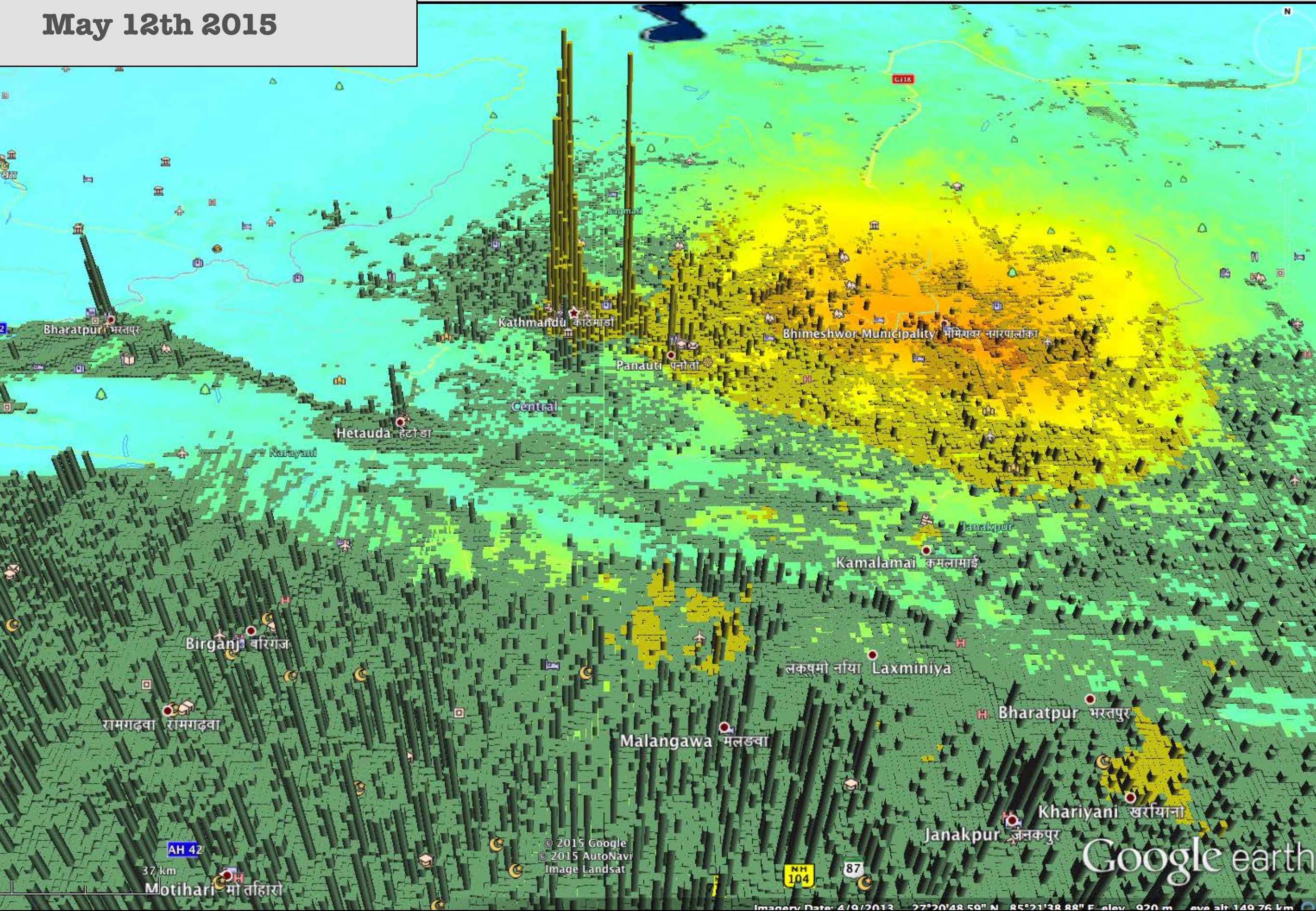
MMI City	Population
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VI Kodari	2k
VI Bhaktapur	< 1k
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VI Zuobude	< 1k
VI Camgyai	< 1k
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bold cities appear on map (k = x1000)

Exposure

May 12th 2015

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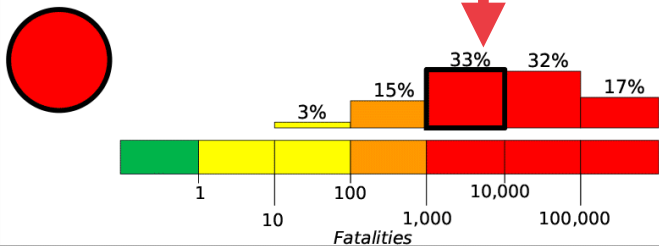


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Alert Levels

Estimated Fatalities

Median Est.

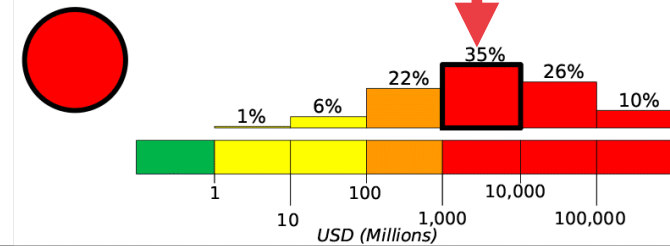


Red alert for shaking-related fatalities and economic losses. High casualties and extensive damage are probable and the disaster is likely widespread. Past red alerts have required a national or international response.

Estimated economic losses are 10-70% GDP of Nepal.

Estimated Economic Losses

Median Est.



Selected City Exposure

from GeoNames.org

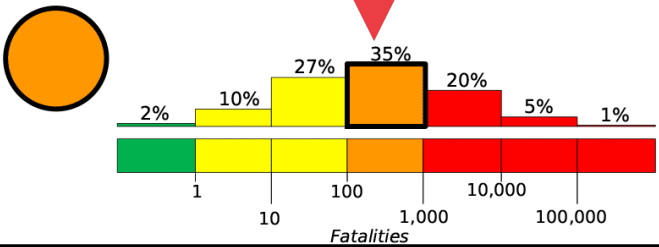
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Estimated Fatalities

Median Est.

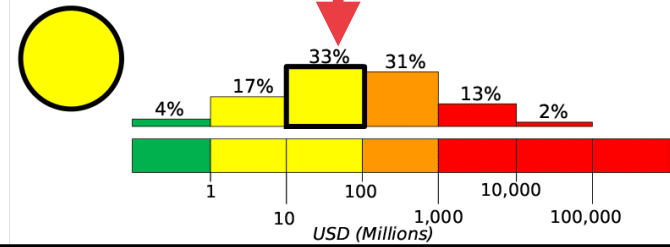


Orange alert level for shaking-related fatalities. Significant casualties are likely and the disaster is potentially widespread. Past events with this alert level have required a regional or national level response.

Yellow alert level for economic losses. Some damage is possible. Estimated economic losses are 0-1% GDP of Nepal.

Estimated Economic Losses

Median Est.



Selected City Exposure

from GeoNames.org

MMI City	Population
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Population per ~1km² from LandScan

Scale of Hazard

0

5

50

100

500

1000

5000

10000

